INVESTIGATION OF TOTAL SUSPENDED PARTICULATE LEVELS, IN AIR, IN THE VICINITY OF THE ST. BONIFACE SHELL OIL REFINERY

by

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Abstract:

A study was undertaken to investigate for elevated levels of particulates downwind from the Shell Oil Refinery in St. Boniface. Of particular interest was how these levels would compare with the Manitoba Air Quality Objectives for Total Suspended Particulates (TSP's), and how the levels at this location would compare with measured levels at four other stations, each representing a different land use environment.

Results indicated that levels occasionally exceed the 24 hour objective, but this doesn't seem to be a result of Refinery activity exclusive of other factors. The estimated annual geometric mean of T.S.P.'s in the Refinery environs is below the Maximum Desirable Level. The comparison with the other stations indicates that T.S.P. levels in the vicinity of the refinery exceed those found at an urban residential station, an urban downtown station and a rural station (baseline). They do not exceed levels found at another industrial vicinity station.

Background:

A high volume particulate survey for the measurement of Total Suspended Particulates was undertaken in the vicinity of the Shell Oil Refinery in St. Boniface from September 1982 to January 1983. Total Suspended Particulates (T.S.P.'s) are particles of

either solid or liquid phase existing in a size and configuration which will allow them to be suspended in air and thus amenable to high volume sampling as outlined in the procedures section.

The sampling site was established on the south side of Fournier Street, just east of the intersection with Panet Road., south-east of the refinery (ref. map in the appendix). Over the sampling period mentioned 52 samples in total were collected at the station, using two "Hi-Vol" samplers, with one sample obtained from either sampler every 2 to 3 days (on average). A schedule of sampling days is given with the results.

A certain segment of the refining process carried out at the Shell facility is regarded as a potential source of particulates, contributing to elevated levels. The procedure in question is the Fluid Catalytic Cracking process. This process catalytically converts the heaviest process streams into light gases, gasoline and distillate. The conversion occurs when heavy oil contacts hot, regenerated catalyst thus selectively breaking down long chain hydrocarbons into smaller ones. As a result carbon is deposited on the catalyst and before the catalyst can be recycled to contact the oil feed again this carbon must be burnt off in the regenerator. This is the suspected source of airborne particulates, and the survey was undertaken to investigate if T.S.P. levels in the vicinity of the Refinery exceed the Manitoba Air Quality Objective (MAQO).

The objective for suspended particulate matter (measured in concentrations of micrograms per cubic metre of air) exists for two specific time period parameters of i) 24 hour average and ii) annual geometric mean concentrations. A Maximum Acceptable Level (MAL) has been adopted which is deemed essential to provide adequate protection for soils, water, vegetation, materials, animals, visibility, personal comfort and well-being. The MAL for 24 hour average concentrations is 120 ug/m^3 and the MAL for annual geometric mean concentrations is 70 ug/m^3. For the annual geometric mean there is also a Maximum Desirable Level (MDL) which is set at 60 ug/m^3. The MDL defines the long term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of Manitoba and for the continuing development of control technology.

T.S.P.'s may originate as a result of industrial process, as is suspected in the case of the Shell Refinery, or they may originate as a result of human activities (e.g. highway traffic) and from natural sources such as wind borne dust.

Procedures:

Using the standard high-volume air sampler, sampling was performed in accordance with the reference method in EPS Report No. 1-AP-73-2 (January 1973), "Standard Reference Method for the Measurement of Suspended Particulates in the Atmosphere (High Volume Method)."

In summary this involves the following prerequisites. It is necessary to use a sampler capable of sampling at an average flow rate of between 1.13 to 1.70 cubic metres per minute for the duration of the recommended sampling period of 24 hours. Sampling is achieved by using an electric motor (pump) to draw ambient air through a filter on the vacuum (intake) side of the pump. In principle, particulates of less than 100 um (.3-100 um) will be entrapped on a clean glass fibre filter, 406.5 square centimetres in area. Total Suspended Particulates (T.S.P.'s) are the mass concentration of suspended particulates in ambient air, expressed in micrograms per cubic metre. This is calculated by measuring the mass of collected particulates (to the nearest milligram) and the volume of air sampled, which is derived from the flow rate (measured to the nearest 0.03 cubic metres per minute) multiplied by the duration of sampling (measured to the nearest 2 minutes). The glass fibre filters must possess a collection efficiency of at least 99% for particulates of 0.3 um in diameter.

Preparation and analysis of filters was carried out at the W.M. Ward Technical Services Laboratory using the prescribed methodology. This methodology consists of the following steps: 1)Filters were visually inspected for contamination or defects and then those accepted for use were identified by numerical indexing in a 10 mm margin around their edge. 2) Filters were then equilibrated by desiccation for 48 hours and weighed prior to exposure. 3) As soon as possible after the 24 hour sampling period, the filter was

collected and subsequently desiccated for a further 48 hours. The desiccation or conditioning process effectively minimizes moisture content of both the filter media and entrapped particulates thus insuring uniformity of results. 4) The desiccated filter was then re-weighed. The initial weight (Step 1) subtracted from this final weight yields a net measurement of Total Suspended Particulates. Average hourly flow during the sampling period can be easily calculated from the "Hi-Vol" transducer chart (which records flow). This average can then be used to generate an estimate of the total volume sampled (in cubic metres). This figure divided into the TSP net weight yields a measurement of the average particulate sampled (in ug's) for each cubic metre over the 24 hour period.

The results obtained from this sampling were then assessed with regards to existing Provincial Objectives and also compared with measurements obtained from four other locations.

The four locations utilized for comparative purposes are taken to represent the following environments:

1) 299 Scotia Street, Winnipeg (NAPS station #70118) is regarded as representative of an urban residential environment.

2) 65 Ellen Street, Winnipeg (NAPS station (70119) is regarded as representative of an urban downtown environment.

3) 800 Marion Street, St. Boniface (NAPS station #70104) is regarded as representative of an industrial environment.

4) St. Francois Xavier, rural Manitoba, representing background or baseline levels.

Results:

The results obtained from the sampling in the vicinity of the Shell Oil Refinery along with the other four stations are tabulated below. Wind direction information was obtained from the Atmospheric Environment Service and is representative of generalized daily wind trends only. Particulate concentration for each sample is given in micrograms of particulate per cubic metre of air (ug/m^3).

DATE	Wind Dir.	Shell Oil Ref. Panet Rd.	70118 299 Scotia	70119 65 Ellen	70104 800 Marion	St. Francois Xavier
82-09-02	WNW	-	20.36	33.59	103.85	21.53
82-09-08	SE	-	63.99	72.78	102.26	56.11
82-09-09	S	159.38	-	-	-	-
82-09-11	S	114.69	-	-	-	-
82-09-14	NNE	-	21.04	16.04	79.81	43.58
82-09-15	S	129.86	-	-	-	-
82-09-16	S	152.46	-	-	-	-
82-09-20	WNW	-	31.20	45.36	93.06	37.43
82-09-21	S	145.30	-	-	-	-
82-09-23	N	83.54	-	-	-	-
82-09-25	S	52.15	-	-	-	-
82-09-26	N	-	25.16	17.36	41.45	28.47
82-09-27	NE	68.24	-	-	-	-
82-09-29	SW	41.35	-	-	-	-
82-09-30	W	64.62	-	-	-	-
82-10-02	WSW	23.31	22.24	0.26	21.54	-
82-10-03	SW	28.17	-	-	-	-
82-10-05	NNE	69.31	-	-	-	-
82-10-07	N	36.21	-	-	-	-
82-10-08	NE	-	18.84	34.74	43.92	8.35
82-10-13	SSW	106.38	-	-	-	-
82-10-14	WNW	115.76	25.94	53.54	119.33	16.53
82-10-16	NW	57.99	-	-	-	-
82-10-17	NW	40.88	-	-	-	-
82-10-20	NNW	140.59	32.95	53.82	126.17	16.90
82-10-21	S	100.81	-	-	-	-
82-10-23	S	81.94	-	-	-	-
82-10-24	SE	64.58	-	-	-	-
82-10-26	SSE	119.88	67.20	119.66	80.34	53.02
82-10-27	SSE	119.59	-	-	-	-
82-10-30	W	41.25	-	-	-	-
82-10-31	SE	53.80	-	-	-	-
82-11-01	SE	-	-	54.91	83.58	24.88
82-11-02	NW	76.76	-	-	-	-
82-11-03	NW	109.33	-	-	-	-
82-11-06	W	54.29	-	-	-	-
82-11-07	W	44.10	22.66	24.64	38.79	16.16
82-11-09	SE	75.07	-	-	-	-
82-11-10	S	46.88	-	-	-	-
82-11-13	S	-	35.40	39.57	75.23	26.43
82-11-19	ESE	-	30.44	49.11	41.40	25.39
82-11-25	W	87.37	37.62	40.40	84.76	25.04
82-11-26	SSE	80.80	-	-	-	-
82-12-01	SSE	27.23	17.65	13.76	22.47	14.53
82-12-02	ESE	23.09	-	-	-	-
82-12-07	WSW	-	50.93	77.51	79.08	17.47
82-12-09	S	60.62	-	-	-	-

DATE	Wind Dir.	Shell Oil Ref. Panet Rd.	70118 299 Scotia	70119 65 Ellen	70104 800 Marion	St. Francois Xavier
82-12-13	N	57.85	27.32	38.43	60.77	13.89
82-12-15	S	49.27	-	-	-	-
82-12-19	NW	-	16.37	14.57	24.66	-
82-12-21	SE	25.18	-	-	-	-
82-12-22	E	17.85	-	-	-	-
82-12-25	S	28.12	25.64	7.03	23.95	6.38
82-12-26	S	14.67	-	-	-	-
82-12-31	S	46.51	38.89	26.15	49.86	5.02
83-01-01	S	18.15	-	-	-	-
83-01-04	W	30.83	-	-	-	-
83-01-05	SSE	22.27	-	-	-	-
83-01-06	NW	-	17.61	18.01	39.28	-
83-01-07	SSE	1.68	-	-	-	-
83-01-10	SSE	17.35	-	-	-	-
83-01-12	S	-	37.77	13.25	36.37	-
83-01-13	E	13.38	-	-	-	-
83-01-14	NW	24.24	-	-	-	-
83-01-18	SE	-	37.46	25.56	28.53	-
83-01-24	NW	-	12.44	10.44	43.82	7.67
83-01-30	WNW	-	20.98	22.18	44.90	7.10
Total No of 24 hr. samples		52	25	26	26	21
24-hr Geometric Mean Particulate Conc. (ugms/m^3)		49.02	27.78	24.65	53.38	18.20
Standard Deviation		2.28	1.52	3.16	1.72	1.99
Range Min.-Max. (ugm/m^3)		1.68-159.38	12.44-67.20	0.26-119.66	21.54-126.17	5.02-56.11
No. of 24 hr. Samples exceeding MAQO*		5	0	0	1	0
Percentage of Total		10%	0	0	4%	0

Of the samples which exceeded the MAQO*, only one was obtained with winds predominantly from the NW quadrant (direction of the Oil Refinery with respect to the monitoring station)

* Manitoba Air Quality Objective for suspended particulate matter, averaged over 24 hours is 120 ugm/m^3.

With the restriction of a very limited number of samples, the data sets (all five) yield geometric means which fall below the Maximum Desirable Level (MDL) of 60 ugm/m^3 for annual geometric means.

Conclusions:

A close examination of the collected data reveals that each set of samples may be regarded as logarithmically normal in their distribution. This is confirmed by the results of a mathematical Davies Test which indicates the existence of log normality. By comparing the characteristic variance of the distribution of the Shell Refinery vicinity data with the same parameter of the other four sampling locations, independently, certain observations can be made.

In comparing the Shell vicinity data to station 70118 we find the statistical distribution of collected samples significantly dissimilar. This is evident by deriving the variance ratio distribution statistic "F" and then utilizing this calculated statistic to assess the similarity of variances of two separate data sets. With the geometric mean of the Refinery vicinity data being almost twice the level of Scotia Street samples it can be concluded that T.S.P. levels in the area of the Shell plant are elevated above those expected in a residential environment.

With regards to the data distribution parameters of the samples collected at stations 70119, 70104, and St. Francois Xavier we find that the variances are not significantly different from the Shell refinery data. It must be noted here, however, that these comparisons are made completely independently and individually. It

would be inappropriate to derive similar conclusions on a Shell data vs. all others basis.

While the Shell data and Ellen Street (station 70119) data display similar distribution characteristics it can be demonstrated using a two sample "t" test that the geometric mean values are significantly higher in the Shell Refinery vicinity. Therefore, it can be concluded that the TSP levels in the vicinity of the refinery are elevated above the urban downtown environment.

In considering the comparison between the Shell data and that of the station 70104 (Marion Street) we again find statistically similar variability in the distributions. It can be determined, however, that the geometric means are in fact significantly different with the higher level recorded at Marion Street. The conclusion here then is that the TSP levels in the vicinity of the Shell station are not elevated above those of an industrial environment.

Finally, it is abundantly clear that, while the Shell data and the background data from St. Francois Xavier may share similar distributions about their respective geometric means, these means are vastly different. The TSP levels in the vicinity of the Shell Oil Refinery are significantly greater than those which we regard as background or baseline data.

Since the four stations used for comparative purposes were all sampled on the same days an assessment of their similarity was undertaken. This would facilitate further examination of the Shell data with respect to the four others. The variances of the other four was established as being equal indicating that on a daily basis there was inherent similarity in their distributions. Further to this it was discovered that the means could not be regarded as equal indicating significant variability between sites. It was revealed that, while the sampling (means) from the Scotia and Ellen stations showed some similarity, in reviewing all four stations the general conclusion was that the variance of the four stations combined compared with the variance of the Shell data indicated that comprehensive testing of the Shell data against the other four could not be undertaken.

It is evident that factors of an indeterminant origin have contributed to the variability among the samples at Shell which prohibit accurate comparisons with the other four stations on a daily basis. Factors which may contribute to this variability are, meteorological conditions, traffic patterns which affect the amount of entrained road dust present, and other "day of week" factors to mention a few. In essence this means that while TSP levels in the vicinity of the Shell Refinery are higher than other locations, it cannot be concluded, with the information available, that this is directly a result of the Refinery.

Summary:

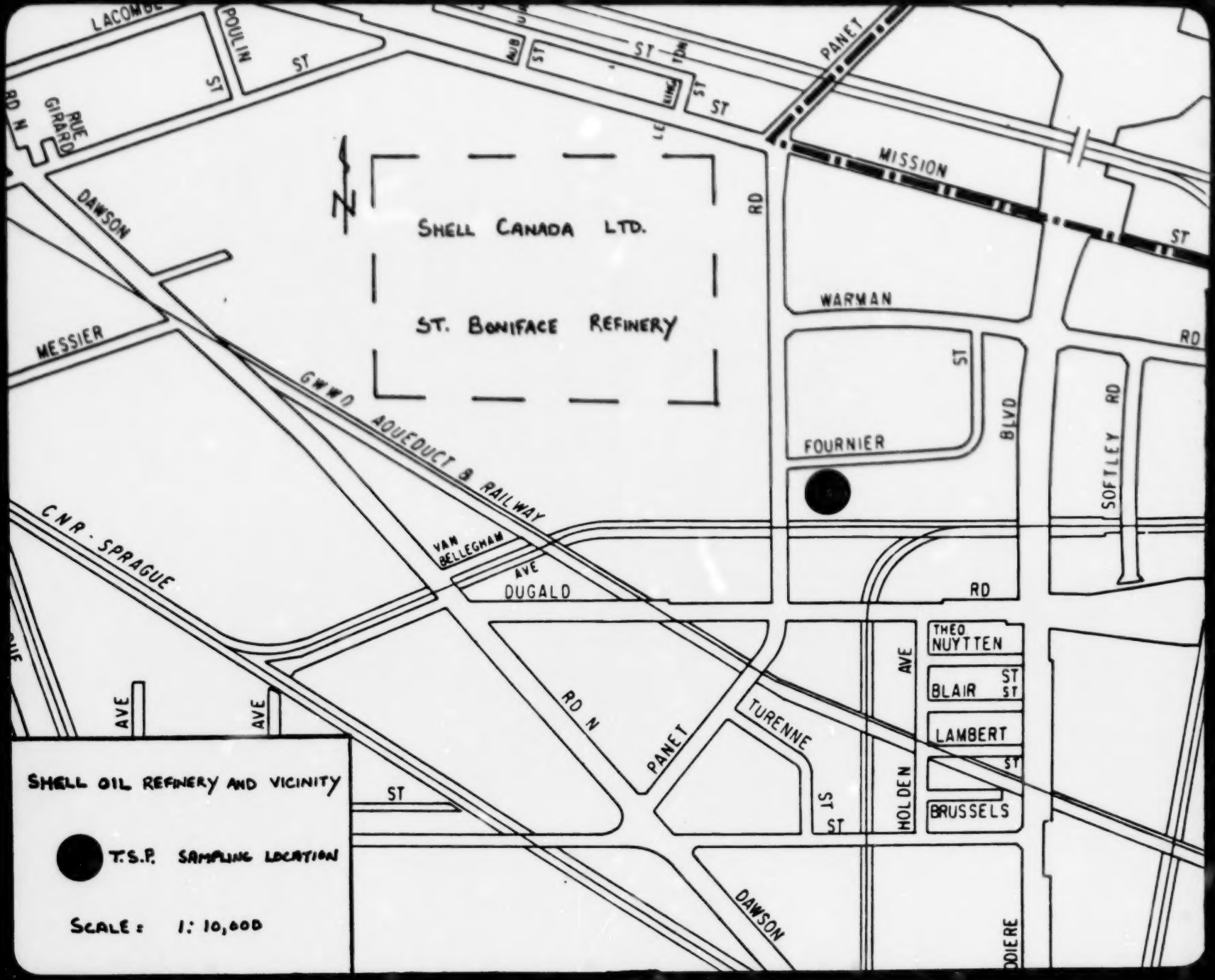
1. It has been shown by the results of this project that T.S.P. levels in the vicinity of the Shell Oil Refinery occasionally exceed the 24 hr. MAL.

2. The frequency of all exceedences is higher than another industrial site (NAPS #70104), but the projected annual geometric mean levels near the Shell Refinery, however, is less than 70104.

3. The "downwind" incidence of exceeded MAL levels (occurring with a NW wind) is only 1/5 of the total at the refinery site. This indicates sources for elevated levels other than the refinery in th area.

4. Levels in the vicinity of the refinery exceed those regarded as characteristic of urban downtown (70119), residential (70118), and background levels.

5. During the period of our investigation the Maximum Acceptable Levels for both the 24 hr. average and projected annual geometric mean were never exceeded at these latter three sites.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